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Case report

Differential diagnosis between cranial fractures of traumatic origin and explosion fractures in burned cadavers

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ABSTRACT

Interpreting the damages on a cadaver which has been exposed to the action of fire is a challenge for the forensic pathologist. The finding of a burned body gives in fact the opportunity to make a series of inquiries which deal with the whole medical–legal practice.

In our case, the victim has been hit over the head with a blunt object and has been then carbonized.

The medical–legal problems implied lie in the definition of the exact manner and cause of death, and therefore in the analysis of vital, perimortal and postmortal injuries, as to formulate a differential diagnosis between the former traumatic originated and the latter caused by combustion.

1. Introduction

It is extremely difficult to formulate a diagnosis of the cause of death when a cadaver has been exposed to high temperatures. The most important task during the assessment phase is to distinguish vital and perimortal wounds from postmortal ones, due to high temperature exposure.

2. Case history

In January 2003 the presence of several cadaver remains was reported in Anzio. We have found traces of a bonfire, ashes and branches of trees partially or completely burned, as well as carbonized cadaver remains still producing smoke. The cadaver lied prone with the trunk in hyperextension, left inclined and right rotated. The head, as well in hyperextension was uplifted from the ground, where the cadaver leaned bilaterally on his forearms. The cranial surface revealed a bone break due to the loss of part of the frontal bone, of part of the left and right parietal bones and of part of the occipital bone, exposing the underlying volume-reduced encephalic substance and ranging from white to a red blackish color.

At first sight, the cranial cavity revealed several fragments of the cranial surface and a detachment of the external bone plate from the internal at the diploë level.

The cadaver rests have been later brought to the hospital for further assessments (Fig. 1).

3. Autopsy findings

The external examination of the corpse highlighted subungual cyanosis of the hands.

The autopsy showed a pulmonary edema associated with congestion.

The pericardial sac, undamaged, contained about 500 cc of fluid blood and clotted blood around the heart. The heart had a normal volume; the endocardium was thin; the myocardium was dark red and his consistency was increased. The coronary arteries were of normal size and hypoelastic with some atheromatous plaques.

The aorta was affected by widespread sclerotic and atheromatous plaques; in the ascending tract was observed a lesion, with irregular infiltrating margins of tunica intima, extending to the outer surface of the wall, and in its full-thickness.

4. Laboratory inquiries

The cranial vault has been partially reconstructed using bone fragments found during the investigation. It wasn't possible to reconstruct the whole cranial surface because some of the bones had been completely incinerated. The exam of the skull revealed the following:

- detachment, in some regions, of the external bone plate from the internal bone plate at diploë level;

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Fig. 1. Crime scene.

Fig. 2. A view of the skull base. Fracture lines are not apparent macroscopically.

- an “eggshell” fracture configuration of the cranial vault.

At a stereomicroscopic exam the diffused gathering in extradural space of reddish material with black shades at the skull base, of evident hematic origin, appeared consisting of a red blackish colored friable surface resembling coffee grounds, with a more compact and homogeneous red portion. The skull base was intact at a macroscopic examination. The use of a stereomicroscope revealed:

- a fracture rim in the frontal part of the cranial base, on the orbital roof, continuing the fracture rim of the frontal bone and extending itself from left to right, from up to down, forwards to backwards, and interrupted a few centimeters from the cribriform plate, with normal borders; next to the borders there were few reddish micro-granular masses of probable hematic origin;
- on the middle left cranial base, on the most caudal portion of parietal bone, a half-moon shaped fracture rim with frontal concavity directed itself up to down, back and forth, interrupted at temporal-parietal suture level, with regular borders; it crossed on its way another fracture rim partly delimitating a “bone plug”; at the borders level there were few reddish micro-granular masses of probable hematic origin (Figs. 2–4).

5. Discussion

The finding of a burned cadaver gives the forensic pathologist the chance to deal with a series of inquiries which embrace the whole medical–legal practice: from investigation to identification, from damages to death chronology evaluation, from toxicology to forensic hematology.[1] The inquiries are determined by the fact that carbonization phenomena on temperatures higher than 800°,[2] cause alterations on the body and great transformations on the skin, by compromising or canceling fingerprints and other revealing details, dental, skeletal or visceral morphological changes, and other organic alterations that adulterate useful elements in defining the time of death. The medical–legal

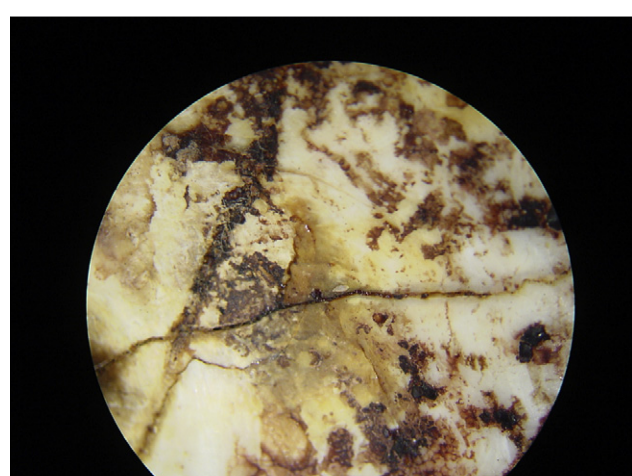

Fig. 3. Skull base fractures detected by stereomicroscope.

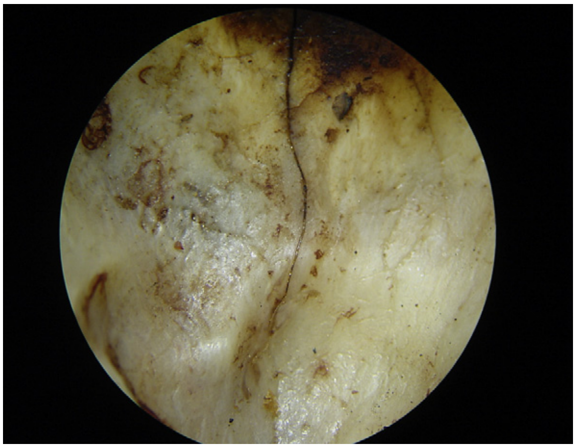

Fig. 4. Skull base fractures detected by stereomicroscope.

problems beneath the present case lie in the definition of the exact cause of death, and in the analysis of vital, perimortal and postmortal injuries, the elucidation of which makes a differential diagnosis possible. The intense and prolonged action of heat causes heat-related fractures which are harder to diagnose than those due to mechanical factors, especially at skull level.[3–5]

The bone tissue is formed by a half cellular and extracellular structure of collagenic origin, which becomes mineralized through calcium and phosphate deposition in hydroxylapatite crystals form.[6] From a functional point of view, collagens is traction resistant, while hydroxylapatite crystals give hardness and resistance to compression. At high temperatures, collagens dehydration diminishes bone elasticity dramatically altering its structural integrity and determining contraction, distortion, deformation and finally fracture. At cranial level, eggshell fractures and extradural postmortal hematoma are very common.

However, experimental studies and casework experiences have demonstrated that trauma evidence survives to carbonization. Pope and Smith,[7] through carbonization of 40 human skulls, analyzed the degradation progress of soft tissues and bones, revealing the pathogenetic mechanism that interest heat-related cranial fractures.

The theory stating that the presence of fractures or of the explosion of the skull stands itself as a proof of the absence of preexistent traumas to the carbonization, has been denied. On this assumption, a skull without traumatic signs, explodes because of the steam produced during brain combustion, when exposed to high temperature.

Observing non traumatized skulls at high temperatures has revealed that soft tissues burn and that heat destroys simultaneously both the organic part of the bone and the internal brain structures. During the study, none of the skulls exploded; they were only affected by normally related events to fire scenes, such as detritus fall, heat diminishment, fire extinction.

Therefore external events and bone structure alteration are responsible of the explosion fracture appearance. The same study has pointed out some useful elements that help identify traumatic bone injuries, which irradiate to non-carbonized cranial regions showing eroded borders, deformed from the action of heat. High temperature caused fractures have clean, sharp and easily matching borders. It might be very useful for the pathologist, in case of doubt about the pathogenesis, to compare the analyzed injuries with the limitrophe heat-caused ones.

To solve the problem, Herrmann and Bennet[8] conducted a study using wild boar bones (sus scrofa genre), that were submitted to several traumatic events and later exposed to high temperature. The results obtained by radiographic inquiries have been compared to the previous heat action and, with the help of an electronic microscope during the reconstruction, the following has been reported:

- bigger fragments are associated to traumatic mechanisms;
- perpendicular fracture rims are mainly related to heat;
- blunted fracture borders are trauma related;
- traumatic and heat-related fractures have very similar characteristics when they are longitudinal; the authors underline the need to make further researches in this direction.

A very interesting study was made by Holden et al.,[5] pointing out with the help of a scanning electron microscope, the deep changes that occur in the bone tissue ultra-structure under high temperature exposure. The research analyzed the changes of tissue related to temperature of exposure, and created a grade which is able to identify whether the body is that of a young person (1–22 years old), of an adult (22–60) or of an elderly person (over 60).

Very close to our reported case is that of Iwase et al.,[9] who analyzed the skull of a woman carbonized and later buried. The beheaded body was found a few days after her death, while her head only four months later. The skull reported a fracture on the left temporal bone with carbonization signs. The investigators thought that the fracture had occurred after decapitation and that the cause of death had been asphyxia.

The fracture line in that region was prolonged to the cranial base, suggesting that it had not been caused by heat. A magnetic resonance marked the presence of a blood clot in left mastoid cells where the fracture line was irradiated, suggesting that the fracture was vital and that the bleeding took place after beheading. The observed injury assessment was characterized by numerous fractures on the cranial vault and by a gathering of red – black striped matter of probable hematic origin in extradural space. At macroscopic examination, the fracture complex on the cranial vault was compatible with eggshell fracture assessment caused by the action of heat.

The fracture rims at the level of the skull base observed with a stereomicroscope and invisible at macroscopic observation, were very important in order to formulate a diagnosis of the cause of death. One was located in frontal cranial fossa as a direct irradiation of the fracture rim involving the left frontal bone, and the other one in the middle left cranial fossa. Through the microscope those fractures of the base looked linear with regular borders. The fracture rim borders appeared reddish and several gatherings of micro-granular red material, compatible with the hypothesis of hematic infiltration, were found inside.

The fracture rims at the base of the skull were compatible with vital fractures, confirming the hypothesis that they had been inflicted before death.

The collection of red material at the base of the skull in extradural space seems to suggest a blood clot. Extradural hematoma is caused by the action of heat, that has to be distinguished from the hematoma of traumatic origin. Extradural hematoma by heat is caused by the passage of blood from the diploë and the veins to the epidural space, has a sponge consistency and is located at the top of the occipital zone. In this case, the collection of red black-shaded material, fragmented on the surface and homogeneous in depth, was compatible with an extradural hematic collection, diffused at the base and correspondent to fracture rims in anterior cranial fossa and in left middle cranial fossa. For its morphological features and for its position at the base of the

skull, the collection of material suggested that the hematoma was caused by a trauma.

6. Conclusion

The problems we have dealt with, have helped us determine some important elements to consider when analyzing the cadaver of a victim of carbonization. Besides the use of more complex procedures, our aim was to point out the need of a detailed analysis of the cranial base as well as the practical importance of stereomicroscopic examination, that made it possible to observe small vital pre-mortem caused fractures. Another relevant element that must be considered while analyzing such an injury assessment, is the postmortal extradural hematoma, caused by the action of heat. This kind of hematoma, if present, must be distinguished from that of traumatic origin. Its aspect, its location and relation to eventual traumatic injuries make a reconstruction of the etiopathogenesis of blood clots possible.

Conflict of interest

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Ethical approval

None declared.

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